Site selection has a major impact on the immediate natural community and the future occupants of the building. Thoughtful placement of the building on the site promotes energy conservation by taking advantage of natural site features such as breezes, sunlight, shade, and topography. Minimal site-clearing reduces costs, and undisturbed plant materials may provide a low-maintenance landscape that avoids supplemental irrigation and fertilizer. Mature stands of native vegetation often provide the desired energy-saving shade and wind control that would otherwise require years to develop from expensive new plantings. Distinguish between deciduous and evergreen trees. Evergreens provide year-round sun and wind protection; deciduous trees protect in the summer and expose in the winter—which can be good or bad, depending on climate.

Action Moment

Building orientation is an action step permitting passive design features and non-mechanical measures to conserve energy, utilize solar energy for thermal gain, and direct prevailing winds for natural ventilation and cooling. Natural conditions should be utilized to full potential to reduce the use of more expensive mechanical systems. For example, in the snowbelt, proper building orientation can use the sun and wind to help clear driveways and parking lots naturally.

Technical Information

1 **Site inventory surveys** should be thorough and objective, and consist of foundation, vegetation, and wildlife habitat surveys. A foundation survey includes all structures and physical construction on the site, including topography, soils, and hydrology. Vegetation surveys show the location and character of all important plants. Wildlife habitat surveys recognize unique and dynamic site aspects.

2 **Proximity of trees to structures** and constructed features should take into account growth rate, life span, and ultimate canopy shape. This includes the balance of desirable qualities of shade with loss of future solar access. When existing tree populations are too dense, selective thinning and lifting the canopy will improve air movement, enhance ground- level vistas, and allow remaining trees better development potential. Special care should be used in construction near trees. Important plant areas and trees to be retained should be effectively barricaded to prevent trespass toward the tree closer than the outer perimeter of branches. Tunnel for utility lines instead of trenching near trees. When cutting roots and limbs, cut cleanly. Water well before major cutting to invigorate the tree. When major roots are cut, light canopy pruning will reduce transpiration stresses.

3 **Soil surveys guide plant selection** and irrigation system design. Soil analysis based on random sampling should report soil type, soil pH, total soluble salts, and infiltration rate. Soil texture, percentage of organic matter, and water holding capacity should also be determined. County Agricultural Extension Offices can perform these analyses for a modest fee.

4 **Preserve high-quality habitat** in areas as large and circular as possible and connected by wildlife corridors. High-quality habitat supports a relatively greater diversity of plants and animal life than other nearby habitats. Size of habitat and corridor requirements vary widely by species. Endangered species and species of special concern vary widely by region. For details of habitat protection and corridor design, contact the local office of the state's Department of Natural Resources; or the regional offices of the U.S. Department of the Interior or U.S. Environmental Protection Agency.

5 **Channel development** into areas that are already disturbed. Existing infrastructure, facilities, and cleared areas may be used with resultant savings. Restore and enhance ecological functions damaged by prior site activities that are obsolete. Revegetation, waterway restoration, and habitat reconstruction are immediate opportunities.

6 **Temporary storage** of materials, vehicle parking, and other disruptive construction activities should be limited to areas of the building site that will be permanently altered.

7 **Significant wetlands** and significant uplands should be protected by design. These designations are variously interpreted by region, state, or district. This variability does not diminish the importance of protecting and enhancing these natural features.

8 **Retained wetlands** and natural water bodies should be insulated from construction activities and post-construction site functions by effective upland buffers.

9 **Natural drainage systems** should be used wherever possible. During construction, take all precautions necessary to prevent erosion and siltation of these natural features. Ensure, by design and specification, that water moving offsite from extreme storm events after construction will not cause environmental damage.

10 **Transplant preservable vegetation** from the construction footprint to the landscape site. Ideally done during plant dormancy, with pre-dig invigoration by watering and light feeding, and with incremental digging of rootball, transplanting can occur nearly year-round. When possible, gather seeds prior to disturbing the site for redistribution after construction or for growing under nursery conditions.

11 **Driveways and parking** should be located on the east or north side of buildings in southern climates. This reduces heat buildup during hot afternoons. Existing or installed shade trees can cool these surfaces.

12 **A "wind rose" is a diagram** of annual wind directions and velocity for a particular region. It is useful for plotting information on winds in order to provide natural shielding from adverse winds and utilize favorable winds for passive cooling measures. Wind rose information is available from the nearest airport, reference librarian, or County Agricultural Extension Office.

 **Existing irrigation systems** can be retrofitted with more water-efficient devices. Depending on water source, in-line filters may be needed. Pressure-reducing devices will generally be required to support low-volume watering. Downsizing from high-volume devices to mist, micro-spray, drip emitters, porous pipe, and similar technologies are well understood by professional irrigation specialists. Digitally programmable, multi-zone timers with soil-moisture limiting switches should be used. With low-volume irrigation, many multi-zone systems can be reduced to fewer zones because of water volume reduction per unit time.

Rectangular buildings should be oriented with the long axis running east-west in regions where solar heat gain is a major annual energy burden. Short-length walls receive less direct sun and the total heat load of building is reduced.

Good general landscaping practices allow facility managers to combine immediate action plans with the long-term benefits of incremental improvements in grounds maintenance. The objective is to create landscapes that have positive environmental impacts and reduce energy use.

Good landscaping practices reduce the use of harmful pesticides, minimize use of potable water, and decrease stormwater runoff.Good practices include choosing appropriate plants, irrigating efficiently (if at all), and considering reclaimed waste water or harvested rainwater for irrigation.Other benefits of good landscape include: complementing natural elements of local ecosystems; preserving the inherent beauty and functionality of the site; maintaining and enhancing local eco-structures and functions to increase diversity and vitality; promoting operational integration of natural processes and social processes; and limiting soil compaction.

Trees planted around buildings create a pleasant environment and can cut energy bills.

Technical Information

All landscapes change, grow, and evolve in a process of succession. By sensitively working with these natural dynamics, good landscaping can provide economy, efficiency, and satisfaction for the workforce.

Good general landscape principles consider site functions for humans and wildlife and anticipate cycles of use throughout the day, week, and year. They foresee extremes of climate, annual solar angles with patterns of light and shade, annual direction and intensity of breezes, seasonal color of flower and leaf, and create a dynamic of vista.

1 **Appropriate plant selection** means “using the right plant in the right place.” This refers to using native or other plants well-adapted to planting conditions and consistent with the intent of the landscape design. Plant growth rate; mature size; life span; brittleness; and light, water, and soil pH requirements are important factors in selecting vegetation. By matching plant requirements with site realities, and by correctly placing appropriate plants, expensive and time-consuming problems can be avoided. Thoughtful selection and siting of trees, shrubs, and groundcover can cut air conditioning energy use 5% to 20%.

2 **Efficient irrigation** is accomplished by grouping plants with similar water needs. Design irrigation systems to avoid over-watering by using ultra-low volume distribution devices. Irrigate after on-site inspection or electronic sensing of moisture need, rather than by schedule. Water requirements vary greatly by season. As the landscape matures, less irrigation is required—especially when native or well-adapted plants and thick mulch are used. Automatic irrigation controllers should have rain switches that override the on-signal when sufficient rain has fallen or soils are moist.

3 **Reclaimed waste water**, sometimes called Irrigation Quality or IQ water, is another possible source of water for irrigation. It is often available at attractive rates from a nearby utility. It must be scrupulously isolated from potable water distribution, and all IQ hose bibs must be clearly marked as "non-potable." Section 4.3 discusses possible uses of reclaimed waste water.

 **Rainwater harvesting** in specially designed above- or below-ground cisterns can reduce the use of potable water in landscapes. Careful planning is needed that considers anticipated water needs, rainfall patterns, space requirements, engineering design, construction cost, maintaining water quality, and means of actually distributing stored water. Cisterns may have a collateral use as thermal reservoirs for heating/cooling systems. Section 4.4 discusses rainwater harvesting in more detail.

 **To pave surfaces in landscaped areas,** use loose-set masonry units, flagstones, gravel, turf block, "geo-webs" (flexible or rigid synthetic grid structures), crushed shell, mosaics of reused concrete slab, and forestry-derived materials. A bedding of crushed, recycled concrete improves drainage and may serve as a useful application for an otherwise difficult-to-dispose-of material. Poured-in-place pervious concrete may be suitable for some applications. Large expanses of black, unshaded pavement will increase the energy consumption of nearby buildings.

Mulches hold soil moisture; reduce weed growth; slow erosion; build soil texture; increase root density by keeping soil cooler in summer and warmer in winter; and, feed important soil microorganisms, which, in turn, buffer soil pH. Mulches add color, texture, contrast, and definition. Mulches can consist of leaves; grass clippings; shredded wood from site clearing, utility, or commercial sources; pine bark; pine straw; nut hulls; or saw dust. Under deciduous trees, leaf litter eventually becomes mulch if left undisturbed.

 **Turf grass** should be limited to recreational areas rather than used in mass planting. This allows major reductions in water, chemicals, maintenance energy, pollution, noise, and labor. Where turf is used, selection should consider the local climate and growing conditions. Alternatives include various combinations of low-growing ground covers, ornamental grasses, wildflower meadows, and decorative mulches. Turf can be expected to decline as tree canopy density increases. As this happens, a transition to mulch, leaf litter, and/or shade-tolerant plants is recommended.

Graywater from hand-washing sinks may be used directly for hydrating plants—but only in a drip-mode, not sprayed.

Cypress mulch should not be used because its harvest depletes an important tree population.

Crushed stone and pebbles are durable but do not contribute to organic content of soil. They hold and reflect heat, which may increase water needs of nearby plants. Crushed shell also may raise soil pH.

References

Executive Memorandum on *Environmentally and Economically Beneficial Practices on Federally Landscaped Grounds*, April 26, 1994.

Georgia Cooperative Extension Service, *Xeriscape—A Guide to Developing a Water-Wise Landscape*, Atlanta, GA, 1992.

Contacts

For local consulting on landscape and soils issues, contact your local County Cooperative Extension Service or the National Resources Conservation Service.

American Society of Landscape Architects, 4401 Connecticut Avenue, N.W., 5th Floor, Washington, DC 20008 (202) 686-2752 or at Home Page http: //www.asla.org/asla/

Enviroscaping involves landscape modifications using plants to increase or decrease the impact of sun and air movement on the local environment and microclimate. These actions can complement and amplify structural modifications of buildings that are intended to conserve or utilize natural and mechanical energy. Plants provide economical means of modifying microclimate and are an investment in future energy savings. Plants create cooler temperatures by evaporating water from their leaves and, depending on humidity, can lower outdoor air temperature several degrees. A surface covered by plants will produce less glare and make the natural light more pleasant and usable. Energy and water efficiency does not mean wild, ragged, or arid landscapes. A well-designed enviroscape can cut air conditioning use 5% to 20%.

Action Moment

Water-balance the site by retaining stormwater with earth shaping, pervious surfaces, detention, retention, and rainwater harvesting. Swales, berm, and other earth shaping can be attractive design elements. They create hydro-zones for plants with similar water requirements, and can add attractive water features to landscapes. This simplifies irrigation design and reduces the cost of installation and maintenance. Man-made water bodies and earth shapes should be designed for maximum habitat value as well as engineering objectives. Landscape maintenance cannot be avoided, but it can be minimized through good design, planning, and intentions to work with, rather than against, natural processes. Landscapes do not require a severe, clipped, geometric regularity.

Technical Information

1 **Soil humus** is built by incorporating leaf litter and lawn clippings as well as other organic mulches. Plants need nutrients but these are largely created by photosynthesis. They do not need artificial, synthetic, chemical food. Native or adapted plants, suited to site conditions, will thrive with minimum effort and resources. Chipping locally derived wood waste for mulch can be less expensive than disposal and purchase. Apply mulch initially about 3 inches deep—except at trunks of trees, because over-moist conditions can harm bark. Top-dress organic mulches annually as they are metabolized into the soil's food chain.

2 **Weed management** is best achieved by prevention and non-chemical means. Mulch will prevent most weed seeds in the soil from germinating. Weed seeds will still arrive and hand removal before seeds are released is most effective. Weed control in lawns is aided by less frequent mowing, because increasing shade will reduce weed germination. Taller grass will have more photosynthetic surface and cool the soil, grow more vigorous roots and need less irrigation. Hand weeding is less expensive, less dangerous, less noisy, and is healthier for workers and the environment.

3 **Integrated pest management** requires periodic scouting for evidence of disease, pest insects, or other symptoms of deterioration. Simple, manual, nontoxic measures are sufficient if taken early. Recognize beneficial insects. They generally follow pest populations. Understand the useful roles of insect predators like birds, toads, lizards, spiders, and bats. These allies need habitat, shelter, food, water, and freedom from harassment. For environmental, economic, and human health reasons, toxic chemicals should not be used, except on a spot basis when all less toxic controls fail.

4 **Arbors and trellises** over walkways and outdoor activity areas can provide attractive and functional shade. Such shade can benefit nearby walls and windows. Deciduous plants will allow winter sun to provide warmth and light.

5 **Trees are valuable assets** for passively enhancing the interior comfort of small and medium-sized buildings especially in warmer climates.

Once established, most trees require little maintenance. Shade and air movement modification depend on height, growth rate, seasonal leaf persistence, canopy shape and density, seasonal solar angles, wind velocity, proximity, and height of structure. Generally, trunks of trees that grow to less than 40 feet tall can be 10 feet from walls. Trunks of trees growing over 40 feet should be no closer than 20 feet from walls. To allow air movement, lower branches near buildings should be removed as the tree grows.

6 **Shrubs can be wind buffers and guides**. Evergreen shrubs planted closely together and somewhat near a building wall can create a "dead-air" space of thermal insulation to reduce secondary heat loss in winter. In summer, these same shrubs can provide cooling by evaporation and by shading early and late sun from walls. However, maintaining a 2-foot clear-zone between shrubs and wall allows for maintenance access and reduces mildew on exterior surfaces. Where operable windows allow natural ventilation, proper pruning of shrubs will not block air flows or views.

7 **Simple, flowing designs usually require less maintenance**. When choosing and placing plants, an expectation of their mature size and form aids in site selection. The number of plant species is easily limited by creating well-defined areas for planting and by arranging plants in groups to create mass effects. Planting beds around tree groups can simplify trimming, reduce mower damage to tree trunks, and increase mowing speed. Structural edging of planting beds creates a clean line and reduces the need for mechanical edging.

8 **There are many effective, commercially-available, biological controls** that harness pest-specific growth-limiting hormones, predatory bacteria, microorganisms, and other complimentary creatures. If native or hardy adapted plants are used, pest and disease problems generally will never get out of hand. Plants not stressed by over-feeding, over-watering, or extreme cutting will be naturally resilient to predation and disease.

9 **Solid outdoor surfaces** such as concrete and asphalt reflect and retain a great deal of heat and should be kept to a minimum unless these qualities can be made seasonally useful by design.

 **Invasive, non-native plants vary by region**. Because of their potential to invade and disrupt native plant communities and create other environmental burdens, such plants should not be installed and should be removed if already present. While some such plants are merely discouraged, others may be strictly prohibited. Contact the nearest Department of Agriculture for details.

References

Department of Energy, *Cooling Our Cities*, DOE/CH10093-211, Washington, DC, November 1993.

Environmental Protection Agency, *Cooling our Communities: A Guidebook on Tree Planting and Light-Colored Surfaces*, Washington, DC, January 1992.

Arizona Energy Office, *Shading and Landscaping for Energy Efficiency*, Phoenix, AZ 85012 Tel: (602) 280-1402.

Contacts

County Agricultural Extension Office can provide planting information for enviroscapes.

EPA has determined that the average U.S. citizen today spends 90% of the time indoors, and indoor air pollution levels can be up to 96 times greater than outdoor pollution levels. This makes Indoor Air Quality (IAQ) one of the greatest health concerns in this country. Poor air quality can have a significant impact on worker health and productivity.

Action Moment

Facility managers should not wait to address known problems of IAQ. Become proactive in identifying and solving problems with indoor air quality. Involve workers in the solution and take their complaints about IAQ seriously. Consider IAQ when renovating spaces, maintaining HVAC and other equipment, or contracting for janitorial services.

Technical Information

Three concepts are used to describe the typical IAQ problem: sick building syndrome, building related illness, and multiple chemical sensitivity.

1 **Sick building syndrome** (SBS) is the condition in which at least 20% of the building occupants display symptoms of illness for more than two weeks, and the source of these illnesses cannot be positively identified.

2 **Building related illness** (BRI) refers to symptoms of a diagnosable illness that can be attributed directly to a defined indoor air quality pollution source.

3 **Multiple chemical sensitivity** (MCS) is a condition in which a person is sensitive to a number of chemicals, all at very low concentrations.

Noise and poor lighting often exacerbate symptoms related to IAQ problems.

Volatile Organic Compounds (VOCs), a major source of IAQ problems, are carbon-based chemicals that evaporate easily and emit vapors. Common sources are paints and carpeting, especially carpet backings and adhesives. VOCs are inhaled and easily transported into the bloodstream. VOC source strengths are more important in determining IAQ than the interior ventilation rate. Emission rates from VOCs can vary by a factor or 100 to 1,000, while the greatest variation in ventilation rates may be a factor of 20, illustrating the relative importances of these two factors in IAQ.

Combustion by-products can create hazardous conditions if allowed to accumulate inside a building. Improper ventilation, inoperative or undersized exhaust fans, and improper pressurization of the building can all lead to buildup of combustion by-products.

IAQ Impacts on Health

Category	Sources	Symptoms
Irritation	Formaldehyde, VOCs, combustion gases, particulates, manmade fibers, pesticides	Irritation of skin uppwer airway, eye, nose and throat, headache, erytherma
Pulmonary	Asbestos, combustion gases, formaldehyde, ozone, particulates	Rapid breathing, fatigue, increased infections, pulmonary edema, asthma, allergies, flue-like symptoms
Cardiovas-cular	Carbon monoxide, particulates	Headache, fatigue, dizziness, aggravation of existing pulmonary conditions, heart damage
Nervous System	Carbon dioxide, carbon monoxide, formaldehyde, VOCs	Headache, blurred vision, fatigue, malaise nausea, impaired judgment
Reproduct-ive	Formaldehyde, VOCs	Menstrual irregularity, birth defects
Cancer	Asbestos, radon, combustion gases, VOCs, particulates	Cancer of the lung, stomach, colon

Bioaerosol contaminants can occur over time from HVAC maintenance problems and air infiltration. Relative humidity that consistently exceeds 60% can result from operating deficiencies in removing interior moisture. Common causes of bacterial and fungal growth are moisture in walls, wet carpet that does not dry properly, and standing water in air-conditioning condensate drain pans. Other sources of moisture for microbial growth are chronic water spills, leaky plumbing fixtures, and one-time water disasters.

The best strategy in dealing with indoor air pollutants is to eliminate the four main sources of indoor air pollution: (1) VOCs, particularly formaldehyde, in building materials, cleaning products and pesticides; (2) bioaerosols from both indoor and outdoor sources; (3) combustion gases from appliances and automobiles; and (4) particulates from fibrous materials and combustion gases. Poor ventilation can be a major cause of IAQ problems and properly balanced and maintained ventilation systems that provide adequate outdoor air quantities are necessary.

1 **Air handlers** should be easy to clean and tightly sealed, have a minimum of joints and other dust catchers, and have effective filters.

2 **Inspection of air handlers** should be facilitated by good access doors and light- or white-colored surfaces inside the air handlers to accommodate ongoing inspections.

3 **Condensate pans** inside air handlers should drain fully, and any debris should be removed from the pans.

4 **Fresh air intakes** should be inspected to ensure that poor quality air is not drawn into the building from "short circuits" between exhaust and air intakes, or site-specific conditions such as wind patterns. Look for standing water on the roof, bird feces or nests, and proximity to cooling towers, parking areas, waste stacks, exhaust vents, loading docks or other adjacent sources of contamination.

5 **Floor drains** should be refilled periodically to prevent sewer gas from entering the building through dry traps.

6 **Wall-to-wall carpeting** should be minimized, and the use of carpet adhesives eliminated.

7 **Paints and adhesives** should contain no or very low VOCs. Interior painting should be done during unoccupied time, such as weekends. Adequate "airing out" should be done to remove the majority of the VOCs from the air prior to re-occupancy.

8 **Durable building materials** should be used to eliminate the need for strong cleaning chemicals. For example, ceramic tile makes a good substitute for carpeting in entry areas and hallways.

9 **Vinyl wall paper** should not be used on interior surfaces of exterior walls where moisture in wall cavities can condense on the back of the vinyl and harbor hidden mold growth.

10 **"Wet" applied** and formaldehyde-containing wall coverings should be minimized.

11 **Ventilation, temperature and humidity** should comply with ASHRAE Standard 62-1989.

12 **Isolate renovation work areas** with plastic sheeting. Tape-off HVAC ductwork in renovation work areas to prevent dust and debris from entering the ducts.

13 **Newly installed materials,** such as carpets and other flooring products, should be "aired out" before installation.

References

EPA, *Building Air Quality: A Guide for Building Owners and Facility Managers*, EPA/400/1-91/033, DHHS (NIOSH) Publication No. 91-114, December 1991.

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality.*

Indoor Air Review, monthly newsletter, IAQ Publications, Inc., Bethesda, MD

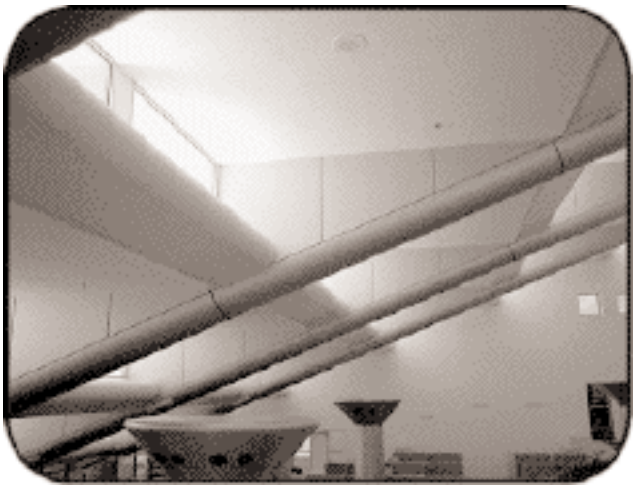
Daylighting and artificial lighting are required in order to perform visual tasks, to provide views to the outside, and to provide a connection to the daily rhythms of the natural environment. Sunlight provides an equal spectral distribution of visible light frequencies to produce 'white light' and provides the truest color rendition. Artificial light is limited in the frequencies it can emit, often producing blue- or yellow-tinted light. Lighting levels and distribution can either enhance or detract from the efficient use of both daylighting and artificial light for energy savings and occupant comfort. The two components of interior lighting are ambient and task lighting. Ambient lighting provides general lighting for orientation and background visual identification. Task lighting provides focused lighting, which will aid in the performance of concentrated and small-scale tasks such as reading. Windows and light fixtures should be properly located and balanced to provide the most efficient and visually pleasing lighting in interior environments.

Action Moment

Additions offer opportunities to plan for daylight through the glazing, exterior wall, and roof designs. There are interior measures that can be utilized without any changes to the building envelope and some that can be applied in conjunction with normal space usage changes.

Technical Information

Daylighting is integral to the building shell and will always require modification of the exterior envelope to provide it in retrofits. Artificial lighting requires integration with building electrical systems and controls that may be prohibitively expensive, depending on the extent of the interstitial space modifications that are required. Lamps and fixtures are the most easily modified components of the lighting system, depending upon power supply voltages.



Daylighting can help create healthy indoor environments and save on utility bills.

1 **Daylight factor** is the percentage of available outdoor light that illuminates an interior space. Simple to moderate tasks require a daylight factor of 1.5 to 4.0.

2 **Many products are available to bring daylight into building interior spaces** and distribute it to the best advantage while mitigating the potential negative effects of heat gain and loss, and excessive glare. Architectural devices can be used to redistribute daylight by diffusion and reflection, eliminate excessive illumination, and prevent glare and direct solar radiation. Devices include: overhangs, exterior and interior light shelves, reflective blinds, window design and selective glazings, roof monitors, atriums, and skylight collection devices.

3 **Incandescent lamps provide the best color rendition of natural light** but are also the most energy intensive. Energy-efficient fluorescent lights are available with coatings that more closely reproduce natural "white light." Full-spectrum lamps that are specifically designed to reproduce natural light also are available.

4 **Monotonous lighting levels and poorly distributed light** that produces glare can create uncomfortable conditions for building occupants.

Glare is produced when the position of the light source and its intensity create extreme contrasts that the eye is unable to adjust to. Flickering ballasts are a significant source of discomfort to office occupants.

5 **Interior space partition changes offer** opportunities for removing full-height walls, within structural constraints, and replacing them with partial-height open-plan partitions. These allow perimeter windows and interior fixtures to distribute light as widely as possible. Interior windows on perimeter walls and over doors allow for internal spaces to borrow perimeter daylight.

6 **Daylight is more useful as a substitute** for ambient lighting than task lighting because of the difficulty of control. Spaces that occupants do not inhabit for long periods of time, such as lobbies, corridors, and transient gathering spaces, are prime spaces for daylighting.

7 **The position and type of the artificial light** source reflector or window can increase the usable light without producing glare. Uplighting and windows that are adjacent to light-colored surfaces will spread light more widely and produce less extreme gradations between the source and the viewer's eyes. Avoid windows that look onto highly reflective exterior surfaces.

8 **Interior fixtures located and fitted with diffusers** that "cutoff" a direct view of the lamp by the occupant, and pendant fixtures that can be hung flexibly below permanent ceiling heights, provide for better use of artificial lighting.

9 **Sun-tracking devices, concentrator devices,** and light tubes are variations on typical skylights that can focus and direct daylight into the interior spaces of a building. Fresnel lenses can be used in conjunction with fiber-optic cables to distribute light to interior spaces at diffuser panels and lenses. Fiber optic cables can transmit light throughout a building with 0.1% to 1.0% loss per foot.

10 **Lighting controls** utilizing combinations of manual switches, photocell sensors, time switching, and occupancy sensors—in on/off, or dimming capacities—can provide flexible and energy-efficient means of controlling electric light usage independently or in conjunction with the use of daylight. Localized controls and appropriate fixture switching combinations will reduce wasteful overlighting.

11 **Daylighting is an important energy** conservation and occupant satisfaction consideration. The best lighting strategy will balance the costs of providing daylighting opportunities, given local daylighting availability and building orientation.

 **Daylighting and artificial light fixtures can be significant sources of heat gain in commercial buildings.** All daylighting strategies need to be designed to minimize heat gain along with the commensurate reduction in the heat gain of the fixture. The additional first costs of daylighting devices—such as light shelves and other daylight collection devices should be balanced against the reductions in costs for interior light fixture—and long term electricity-use costs.

Direct sunlight can damage interior furnishings, and the ultraviolet radiation component of sunlight can combine with volatile organic compounds (VOCs) that might be present to form ground-level ozone, which is hazardous to human lung tissue. VOCs should be minimized as a matter of course, and space planning should specify interior finishes and furnishings that have low to zero VOC emissions.

References

CADDET—Centre for the Analysis and Dissemination of Demonstrated Energy Technologies, *Efficient Lighting in Commercial Buildings*, 1995.

Contacts

FEMP at (800) DOE-EREC for information on lighting and lighting quality.

Building acoustics have traditionally been a low priority compared to other problems faced by facility managers. Yet acoustically-acceptable indoor environments increase worker satisfaction and morale. Irritating and unexpected noises create distractions that reduce productivity. Bathrooms, plumbing fixtures, exhaust fans, mechanical ducts, outdoor condensing units, lawn maintenance equipment, traffic, and airplanes are all irritating sources of noise. Some noises created in building systems, such as fluorescent lamp ballasts that buzz, or HVAC systems that generate and transmit various noises, can be difficult to trace.

Action Moment

Some acoustical issues can be addressed during normal operations and maintenance activities, such as servicing noise-producing equipment. When replacing equipment such as transformers, motors, and air handlers, vibration-isolation techniques can be employed effectively. When spaces are renovated or additions made, design and material selection can help attenuate the transmission of annoying sound into work areas.

Technical Information

Concepts important for addressing acoustical problems in buildings include the following:

1 **Noise criteria** (NC) is the continuous background noise from sources such as mechanical systems, desktop PCs, traffic noise, background music, and the general low noise from the combined activities of dozens of workers in the same space. Background noise is beneficial if it is of the proper level and tonal quality. Above a level of NC-40, background noise interferes with speech and telephone conversations. If it is too low, it fails to drown out intrusive noises and diminishes privacy.

2 **Acoustical privacy** relates to the amount of sound perceived from sources outside a worker's space. The noise is audible when it exceeds the background noise level, and is a particular problem with open office plans. Intrusive sounds include telephones, office equipment, and adjacent conversations.

3 **Speech privacy potential (SPP)** quantifies the percentage of words that can be understood from an adjacent conversation, and is related to sound isolation and background noise. SPP is directly proportional to occupant satisfaction, and GSA recommends a minimum value of 60 decibels for SPP in open offices. As the table on the following page shows, an SPP of 70 decibels is considered good for closed office plans. GSA-sponsored research for open office areas revealed that speech privacy can be improved either by increasing the sound attenuation between work stations or by increasing the background noise. The physical constraints of existing spaces often make background noise enhancement more practical.

Improving acoustics in interior environments requires problem analysis, goal setting, and use of sensible and appropriate solutions. Some of the methods and technologies listed here may help in addressing specific problems within a facility.

1 **Active noise cancellation** (ANC) systems consist of microphones that receive the target noise and speakers that create an identical sound field 180 degrees out of phase with the original noise. The sound field created effectively reduces the effect of the offending noise, but does not cancel it. Some ANC systems are made for use in HVAC ductwork to prevent problem noise from disturbing occupants. In general these systems are expensive and do not have wide acceptance for use in buildings.

2 **High-performance glazing** can be used to mitigate external ground- or air-traffic noise in work areas. Windows with wide air spaces between the glazing units give better attenuation than standard insulating windows.

Degrees of Speech Privacy for Closed Office Plans

dB	Description of Privacy
85	Total privacy. Shouting is only barely audible.
80	Highly confidential. Raised voices barely audible but not intelligible.
75	Excellent. Normal voice levels barely audible. Raised voices are mostly unintelligible.
70	Good. Normal voices audible but mostly unintelligible. Raised voices partially intelligible.
65	Fair. Normal voices audible and intelligible some of the time. Raised voices intelligible.
60	Poor. Normal voices audible and intelligible most of the time.
<60	No speech privacy.

3 **Natural earth berms** and constructed barriers can yield significant shielding and acoustical attenuation. Natural vegetation also augments sound-dampening of physical barriers, but to a limited degree.

4 **Provide separation** of noise-generating areas and noise-sensitive areas. Meeting rooms and offices should not be adjacent to equipment rooms. Instead, bathrooms, storage rooms, and copier rooms are better suited for adjacency.

5 **Air handler noise** transmission can be reduced by providing flexible connections between the air handler and ductwork and by using duct liners. New nonporous duct liners are available that do not support the growth of bio-contaminants.

6 **Partition walls** between offices often stop at, or inches above, dropped ceilings, creating pathways for office-to-office sound transmission in the plenum area. For superior attenuation, run wallboard on at least one wall surface all the way up to the top of the plenum.

7 **Acoustically absorptive** interior surfaces can be coupled with acoustically reflective, hard surfaces to control how sound travels. Sound-deadening panels and partitions can be specified with natural fabrics, which also enhance beauty and minimize problems with indoor air pollutants.

8 **White noise** or sound-masking systems artificially raise the background noise level to maintain speech privacy. They consist of an array of speakers that are usually located above the finished ceiling. Central systems are available for offices that allow adjusting levels at various frequencies to meet the acoustical objectives, similar to the way an equalizer functions on a stereo system. These systems are usually installed to provide a background noise level of NC-38 to NC-42. However, many people find the use of white noise systems objectionable.

References

Foulkes, Timothy J., "Technics: Office Acoustics," *Progressive Architecture*, Sept 1992.

Ortega, Jose, "Acoustical Fenestration," *The Construction Specifier*, Feb 1994.

Longman, John D., "Acoustics," *Sustainable Building Technical Manual*, Public Technology Initiative, June 1996.

Careful operations and maintenance (O&M) procedures are absolutely essential in all efforts to reduce the energy and environmental impacts of the built environment. Even the best efforts of designers and builders are of little use unless those who operate and maintain the buildings and facilities perform their roles with sufficient knowledge about how to "green" their functions. Effective operation and maintenance is the starting point for a resource efficiency program. This guide provides a wide variety of O&M information on the important systems typically found in Federal facilities. This information should be factored into the routine operational procedures of facility managers and can contribute greatly to lowered energy and water costs, higher employee productivity, and a generally improved working environment.

Indoor air quality (IAQ) is becoming one of the greatest concerns of facility managers throughout the world. Poor IAQ lowers productivity, can cause illness, and has resulted in lawsuits. As noted earlier in this guide, there is a wide variety of causes of poor IAQ that may have their origins in the design and construction of the facility. O&M procedures can contribute either positively or negatively to the quality of the indoor air.

Energy consumption is heavily tied to O&M procedures. HVAC equipment must be well-maintained for the complex array of chillers, boilers, air handlers, controls, and other hardware to function at peak performance. A well thought-out, well executed O&M program can provide huge savings in energy and equipment costs.

Water utilization is becoming a bigger issue every day as many regions of the country place increasing pressure on the remaining sources of high-quality, potable water. It would be a prudent assumption on the part of any facility manager that this situation will lead to dramatically increased water prices in the near future as well as possible restrictions on water use in some areas of the country. The sections in this guide on water conservation provide a wide range of possible options for the facility manager. However, none is more important than a routine inspection and maintenance program that verifies that fixtures are operating as planned and that leaks are immediately repaired.

Environmental effects of O&M received only minor attention until concerns about handling and disposal of hazardous materials came to light. Now, facility managers, and everyone else, must pay close attention to the environmental impacts of their activities. As is the case with their other responsibilities, facility managers must take a proactive stance with regard to environmental impacts. Every day, new products and processes become available that claim reduced environmental impacts. The facility manager has to carefully scrutinize these claims to separate those with merit from those of little or no worth. This guide also addresses recycling programs, which may be under the facility manager's jurisdiction. These programs and their supporting hardware need continual attention and maintenance.

Some O&M Greening Strategies to help facility managers integrate the main O&M ideas from this guide into the routine O&M procedures are presented below:

Ensure that the major issues, such as IAQ, energy conservation, water utilization, landscape maintenance, and general environmental effects, are carefully woven into O&M procedures.

Acquire access to publications that feature the greening of the built environment as their theme. Some of these are listed below.

Integrate the ideas in this guide into the routine training programs for O&M personnel.

Start a facility-wide "Green Team" with representatives of all stakeholders to design and activate a facility-wide "Greening" plan.

5 **Incorporate green ideas** into all contracts, maintenance, and procurement.

 By installing a state-of-the-art operations and maintenance monitoring system in early 1993, the Marine Corps Air/Ground Combat Center at Twenty-Nine Palms, California was able to increase its hot water plant capacity by 30% and eliminate the need for a $1.5 million boiler installation. This artificial, intelligence-based system saved $138,000 in natural gas costs during its first year of operation and its advanced diagnostics system is expected to reduce plant maintenance costs by up to 30%.

 **Steps for creating an effective operation** and maintenance program:

1 **Ensure up-to-date operational procedures** and manuals are available.

2 **Obtain up-to-date documentation** on all building systems, including system drawings.

3 **Implement preventive maintenanc**e program complete with maintenance schedules and records of all maintenance performed for all building equipment.

4 **Create a well-trained maintenance staff** with a professional development and training plan for each staff member.

5 **Implement a monitoring program** that tracks and documents building systems performance to identify and diagnose potential problems and tract the effectiveness of the O&M program. This includes cost and performance tracking to allow effective program management.

References

Environmental Building News, PO Box 161, Brattleboro, VT 05301 is a newsletter devoted to environmental issues in the building industry. (802) 257-7300 telephone; (802) 257-7304 fax; Home Page at http://www.ebuild.com; e-mail at EBN @Sover.net

Interior Concerns Newsletter, PO Box 2386, Mill Valley, CA 94942 covers indoor air quality and other environmental issues. (415) 389-8049 telephone; (415) 388-8322 fax.

Meador, Richard, "Maintaining the Solution to Operations and Maintenance Efficiency Improvement," Association of Energy Engineers, *Proceedings of the World Engineering Congress, Atlanta, 1995*.

Szydlowski, R., "No Maintenance—No Energy Savings," Association of Energy Engineers, *Proceedings of the World Engineering Congress, Atlanta, 1995*.

Contacts

There is an advertising-supported webpage that supports idea exchange among facilities managers located at http://www.fmdata.com

Perhaps there is no more visible and important issue facing facility managers today than that of indoor environmental and air quality. Operations and maintenance procedures are of the greatest importance because a healthy indoor environment cannot be sustained without careful attention to routine maintenance, including cleaning.

Action Moment

Good O&M procedures are absolutely essential in order to create and maintain a healthy interior environment. Attention to O&M can actually reverse poor working conditions and greatly improve the work spaces of the Federal work force. Areas for improvement include HVAC system maintenance, lighting bulb and fixture replacement, elimination of sources of unpleasant noise, and general cleaning of the facility.

Healthy Indoor Environment Issues:

What makes a healthy indoor environment? There are several factors that keep the interiors of buildings healthy:

- Proper temperature control
- Proper humidity control
- Adequate outside air
- Low emissions (usually VOCs) within the indoor environment
- Proper cleaning procedures
- Lack of mold- and mildew-producing conditions
- Elimination of smoking

Note that almost every one of these conditions can be either maintained or reversed by O&M procedures.

1 **HVAC and indoor environmental health** are tightly connected. Proper maintenance will ensure that HVAC systems continue to function over their operational life as originally intended by the designer. Controls such as dampers and their pneumatic or electric motors must be checked periodically to ensure their proper operation. Filters have to be changed at regular intervals. Flow rates of chilled water, hot water, cooling tower water, and other fluids have to be monitored to maintain their design values.

2 **Volatile organic compounds (VOCs)** are the greatest chemical source of indoor air problems. When operating and maintaining buildings, all materials used in maintenance should be scrutinized for their emissions properties. Sources of high-VOC emissions are finishes, carpeting, paints, varnishes, sealants, and adhesives. As noted in the Material Selection and Indoor Air Quality sections of this guide, good products are becoming available on the market specifically designed to either eliminate or greatly reduce VOC emissions.

3 **Cleaning procedures** can have significant impacts on indoor environmental health. First, lack of cleaning allows the buildup of dirt and dust, which can become airborne due to a variety of reasons, not the least of which is the movement of people through the building. Second, attention should be given to the types of cleaners being utilized, including disinfectants, waxes, polishes, and cleaning solutions. Some of these merely contribute unpleasant odors, while others actually emit compounds that can make people feel sick.

4 **Other considerations for healthy indoor environments include:**

- Glare-free lighting;
- Good color rendition of lighting;
- Good maintenance of light fixtures; and,
- No irritating noises from lighting, transformers, air handlers.

The General Services Administration is committed to achieving a 50% toxic chemical reduction goal by December 31, 1999 by reducing the agency's total releases and off-site transfers of toxic chemicals. GSA's New Item Program (NIP) promotes pollution prevention technologies and environmentally beneficial products and services, including cleaning products.

References

Sustainable Design and Construction Database, National Park Service, Denver Service Center, Denver, CO www.nps.gov/dsc.dsgncnstr/

Indoor Air Quality Update, monthly newsletter, Cutter Information Corp., Arlington, MA

Contacts

For more information about suitable cleaning products, visit the GSA website at http://es.inel.gov/program/p2dept/general/gsap2.html.

Many buildings occupied by the Federal workforce are leased. The range of actions that can be taken by facility managers may be limited by lease agreements. However, even with these constraints there are still many O&M procedures that can be implemented to reduce the environmental effects of these buildings. The O&M problems of leased buildings are virtually identical to those of owned buildings.

Action Moment

Prior to leasing a building, a detailed survey of all energy and environmental issues should be conducted to ensure that all problems are corrected prior to occupancy.

Technical Information

New Leases for Existing Facilities, Executive Order 12902 March 8, 1994. To the extent practicable and permitted by law, agencies entering into leases, including the renegotiation or extension of existing leases, shall identify the energy and water consumption of those facilities and seek to incorporate provisions into each lease that minimize the cost of energy and water under a life-cycle analysis, while maintaining or improving occupant health and safety. These requirements may include renovation of proposed space prior to or within the first year of each lease. Responsible agencies shall seek to negotiate the cost of the lease, taking into account the reduced energy and water costs during the term of the lease.

In addition to available appropriations, agencies shall utilize innovative financing and contractual mechanisms, including, but not limited to, utility demand-side management programs, shared energy savings contracts, and energy savings performance contracts to meet the requirements of this order. Agency heads shall work with their procurement officials to identify and eliminate internal regulations, procedures, or other barriers to implementation of this order.

Leased Building Issues

1 **Indoor air quality.** One of the greatest contributors to poor indoor environmental quality and poor health is improperly designed, sized, installed, and maintained HVAC systems. A major factor that the facility manager can control is maintenance. A good program of filter changing, control system checks, and air/water system balancing will positively affect the air quality of the interior spaces. Interior finishes can also cause air quality problems. For chemically sensitive people, the effects can be severe. A properly prepared leased space contains low-emission finishes, with particular attention paid to carpets, painting, wall coverings, sealants, and varnishes. Require these in the lease terms. The facility manager can also verify that the building air quality complies with all regulatory and contractual requirements.

2 **Energy consumption.** Depending on the lease provisions, the energy consumption of the building can vary greatly. If a relatively high-energy-consuming building is acquired, there are many options (centering around control systems and lighting) that can dramatically affect operational costs. Energy Management Systems (EMS) that permit HVAC system operation during work hours, and setback controls that vary the temperature setpoints of the building based on time, are generally simple, easy-to-implement measures that will greatly lower energy consumption. High efficiency T-8 fluorescent and compact fluorescent lighting can be installed in place of conventional lighting, providing the same lighting levels at a fraction of the energy input. In every case care should be taken to ensure that all the ramifications of system changes are carefully determined to insure that the desired result is achieved. For example, extensive lighting retrofits to low-energy systems can significantly affect HVAC loads. The same is true of changes in insulation and fenestration. The local power company can provide energy surveys and often will have incentive programs to

help reduce power consumption. Although not an energy issue, control of power demand levels is an important step in reducing costs of building operation.

3 **Water utilization.** Older leased buildings have a high likelihood of having older fixtures with high flow characteristics. There are a variety of devices that can be installed in toilets to reduce water consumption per flush without significant adverse effects on the performance of the fixture. Ensuring that malfunctioning and leaking fixtures are quickly repaired can greatly reduce water utilization. A Water Management Plan as described in section 4.1 provides the basis for the types of cost-effective measures that can be implemented.

4 **Recycling programs.** Reducing the environmental impacts of Federal buildings, whether leased or owned, can be helped greatly by controlling the generation of waste. Paper waste accounts for the greatest quantity of solid waste generated. The implementation of programs to recycle this valuable material is fairly straightforward.

Before Leasing a Building . . .

Contact the GSA to help specify the full set of energy, water, HVAC, and other requirements for the leased space.

1 **Be sure that energy-efficient lighting and reliable control systems are provided** and that their operation is clearly documented.

2 **Require electronic controls** on all fixtures or insist that the lease contains provisions to allow retrofit with electronic controls.

3 **Be sure that full technical**, operational, and maintenance documentation of the HVAC system and its controls are provided to the facility manager.

4 **If a building has lead**, asbestos, mercury, or PCB problems or contamination, do not lease it!

DOE's Denver Regional Support Office (DRSO). In 1993, with its lease expiring, DRSO determined the energy efficient features that would be acceptable in its next leased space: energy-efficient lighting systems, insulation, low-E windows, and energy-efficient HVAC systems. For reasons cited as competitiveness, the GSA included only DRSO's requirements for energy-efficient lighting in the solicitation for its new office space. Working together with in-house personnel, the local utility company (Public Service Company of Colorado) and the building owner, a lighting retrofit was planned and executed.

References

Department of Energy, Federal Energy Management Program, *Energy Efficient Leased-Space Toolbook*, Washington, DC. Available from the FEMP Help Desk at (800) DOE-EREC.

To actually make changes that reduce the energy and environmental impacts of Federal facilities, the various standards, operational procedures and other documents that define how the facilities are managed must be changed. Additionally, a comprehensive training program is required to really foster change in any organization. The contents of this guide can be utilized as the basis for training, and can be supplemented with a wide range of government, industry, and academic information on the energy and environmental issues as they relate to the maintenance of the built environment.

Setting Standards

Leadership by example is imperative in inspiring the deep changes that are required to shift to low consumption and efficient utilization of resources, low waste, and the creation of healthy interior environments. The culture of the organization must be transformed from one that pays little attention to energy and environmental issues to one that has internalized the benefits of using our resources wisely. This kind of change demands firm commitment and leadership from senior management. Consequently it is necessary for the facility manager to educate and inform management regarding how the organization should function, what its priorities should be, and what the “organizational culture" should be.

High standards are the most important ingredient in success. There are abundant standards from a variety of sources that facility managers must follow. However, it is difficult to grasp the wide range of requirements and potential solutions available. Even more critical and difficult are the monetary and financing issues associated with change. The facility manager needs to create a blueprint for those laboring in all aspects of facilities management, from the planners, architects, and engineers working on renovation or expansion of existing spaces, to those performing routine maintenance or cleaning the buildings. This wide range of individuals must be made aware of their roles, both individually and collectively, to make the change to a resource-efficient organization.

Section 1.2 of this guide outlines the **major Federal laws and Executive Orders** that require facility managers to reduce the energy and environmental impacts of their facilities. These should be of prime importance when writing local standards.

Training

High-quality training programs are the key to changing the behavior of the wide range of people involved in the management of Federal facilities. The training must be interesting, relevant, up-to-date, and tailored to the specific audience. It should be action-oriented and hands-on whenever possible. Architects should receive a different pitch on the same subject than engineers or HVAC maintenance personnel.

Who should deliver the training? Training is often a function of money, as is the case with many other issues. In any organization’s budgeting process, setting aside resources for education and training is essential because the success of the organization depends on its employees having the most up-to-date information on their particular work, trade, or discipline. It pays to find the best delivery system possible, whether it be from the government, private organizations specializing in training, industry, universities, or professional associations. Utility companies often have presentations on demand-side management, energy-efficient lighting, and a wide variety of other topics. Manufacturers’ representatives will often agree to participate directly in training because their job is to position their products in the marketplace.

The keys to training—commitment and imagination. For the training to be effective it must have the backing of the facility manager and management and it must be delivered periodically to continually reinforce the priority ideas. The best trainers are creative and imaginative. They maintain high interest levels, and their information is usually retained.

A wide variety of publications is available from government organizations—DOE, FEMP, GSA, DOD, and EPA. An even larger quantity of reference materials is available from the private sector—magazines, books, journals, and technical publications from hundreds of manufacturers and from consensus organizations such as ASHRAE and AIA. The International Facilities Managers Association (IFMA) has an extensive list of publications and training programs that are useful for this purpose.

Videotapes make training more interesting and varied. A training library with a collection of videotapes is a valuable training asset.

Case studies are valuable training aids. A wide variety of case studies about greening of facilities is rapidly becoming available in printed form and videotape. Among them is "Greening the White House." There are also a number of good, relevant examples from the private sector, such as the Audubon House in New York.

References

American Institute of Architects, *AIA Environmental Resource Guide*, Demkin, J.A., Ed., John Wiley & Sons, New York, NY, 1996.

National Audubon Society and Croxton Collaborative, Architects, *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office*, John Wiley & Sons, New York, NY, 1996.

Contacts

The FEMP Help Desk at (800) DOE-EREC can provide a copy of the *FEMP Training Catalog*.

FEMP's Home Page at http:// www.eren.doe.gov/femp and EREN's Home Page at http:// www.eren.doe.gov list examples of Federal Initiatives.

For information about training offered by other governmental agencies, colleges and universities, as well as private sector organizations such as ASHRAE and AEE, call FEMP's Training Course Locator System at (202) 586-5772 telephone; (202) 586-3000 fax (attn: Locator System).

When an organization makes a substantial commitment to change the direction of its operations in order to give high priority to protecting the environment and reducing energy costs, it still must determine what the net effects of all the associated investment and actions have been. This normally will be required by senior management, who need to be able to justify short-term higher-cost budgets for capital improvements to produce long-term benefits. Some of these benefits may be relatively easy to quantify. For example, energy and water quantities and associated costs are provided monthly to the facility manager for the facilities under their control, and the cost benefits of some energy and water reduction measures can be readily determined from those bills. Many other issues are not so readily quantified, for example: durability, maintenance, drought-tolerant landscaping, or good indoor air quality. However, to create a complete picture of the impacts of the various measures selected for implementation, the facility manager will have to perform analyses that cover time spans longer than a year. This is especially true for indoor air quality, where the only measurable quantity—employee productivity—is an indirect measure of improvement.

Technical Information

The FEMP Measurement and Verification (M&V) Guideline provides a methodology for quantifying the savings resulting from the installation of energy conservation measures. The M&V Guidelines help to provide verification of energy savings at a minimum of cost, and are intended for use with Energy Savings Performance Contracting (ESPC) and utility program projects that are discussed in sections 9.3 and 9.4 of this guide. The M&V Guideline was developed by FEMP in parallel with the North American Energy Monitoring and Verification Protocol (NEMVP), ensuring consistency for companies doing business with both public and private sectors.

The M&V Guidelines address a wide range of project complexities by allowing the user to select one of three approaches. Factors affecting costs of measurement and verification include:

- number of energy measures implemented;
- size and complexity of energy conservation measures;
- number of interactive energy conservation measures; and
- risk allocation issues.

EMS tracking features are an effective way for collecting consumption and demand information.

1 **Electrical energy.** Determining electrical energy consumption is relatively straightforward, and an ordinary electrical meter is adequate for simple daily, weekly, or other longer period electrical energy determination. If consumption versus time is required, either the manual method of taking frequent meter readings, or automated data collection are necessary. For collection of time-based information, split-core current transducers (CTs) and power transducers (PTs) can be installed without disconnecting power. Data loggers can be used to collect data which can be downloaded by modem as needed.

2 **Electrical demand.** Time-based information is essential if electrical demand is to be determined, and, in this case, it is essential to have the appropriate software to determine the "peak" value. In reality the peak is normally a time-averaged value over a sliding 15- or 30-minute time frame. Single or multiple spikes are not indicative of the peak as measured by the local utility.

3 **Chilled water and hot water.** Btu meters can be installed to determine energy consumption of HVAC equipment lines: chilled water, hot water, and steam. Simple, reasonably accurate meters can be installed "hot," that is, without needing to turn off the system.

 **Indoor environmental quality (IEQ).** Measuring the benefits of IEQ is very difficult but not impossible. IEQ is an aggregate of the environment created by air quality, light, noise, temperature and humidity. Indoor Air Quality (IAQ) has received the most recent attention, but the other factors also are important contributors to the sense of well-being of the facility occupants.

 **The only way to determine the impacts** of measures designed to improve IEQ is to keep track of how employees are performing. Some of the statistics that may be examined are employee absenteeism, sick days, and productivity. Note that to make sense of this information, the data must be collected for a significant period of time both before and after the changes. The Rocky Mountain Institute (RMI) has conducted several studies linking improvements in IEQ to improvements in productivity. In most Federal facilities, the cost per square foot of the workforce is 20 times greater than the cost per square foot of the building. This huge difference readily demonstrates that investments in IEQ that improve worker productivity and that translate into a rather small cost per square cost, will be rapidly repaid by positive benefits to the work force.

Before making any major energy- or water-system upgrades or improvements, it is useful to have a complete monitoring system installed to be able to determine the effects of the changes.

References

Romm, Joseph, *Lean and Clean Management: How to Boost Profit and Productivity by Reducing Pollution*, Kodansha America, New York, NY, 1994.

Fryer, Lynn, "Tapping the Value of Energy Use Data: New Tools and Techniques," *E-Source Strategic Memo*, Mar, 1996.

The FEMP M&V Guideline and the NEMVP are available through the FEMP Help Desk at (800) DOE-EREC or through the FEMP home page at http://www.eren.doe.gov/femp.

Contacts

For additional information on the Federal Measurement and Verification (M&V) Guideline, please contact Brad Gustafson of FEMP at (202) 586-2204 Brad.Gustafson@hq.doe.gov.

To download the M&V Guideline, please visit the Lawrence Berkeley National Laboratory (LBNL) Home Page at http://www.lbl.gov

Facility managers are required to re-examine their procurement practices to focus on the acquisition of energy-efficient, water-conserving, renewable energy (Executive Order 12902) and products with recovered materials content (Executive Order 12873). Energy Savings Performance Contracting (ESPC) bid documents and specifications must be amended to remove obstacles to the use of products with recovered materials content.

Action Moment

The Federal government is the world's largest single buyer. The facility manager can help increase the availability and reduce the cost of recycled-content, energy-efficient, water-conserving, and renewable energy products by specifying and purchasing these products. FEMP, DOE, DOE National Laboratories, DOD, GSA, and EPA have publications containing a wealth of information and guidelines on these subjects, which facility managers can use to substantially reduce energy operating costs and the environmental effects of their operations.

Technical Information

The Federal Procurement Challenge is a voluntary government-wide program to assist agenciesin meeting the energy and water conservation goals to the Energy Policy Act of 1992 and Executive Order 12902. The Federal Procurement Challenge uses the buying power of the Federal government to:

- Support and expand markets for today's best practice products;
- Assist in the commercialization of new technologies;
- Lower the costs of efficient products for all consumers by providing a large, reliable market;
- Reduce operating costs for Federal agencies, saving taxpayers' money;
- Reduce Federal energy use and greenhouse gas emissions; and,
- Provide a model for government, corporate, and institutional purchasers.

FEMP supports Challenge participants with technical support, product efficiency recommendations and fact sheets, software, Basic Ordering Agreements (BOAs) for specifying energy saving products and services, and help using Energy Savings Performance Contracts (ESPC) to finance long term savings through partnerships with the private sector.

Purchasing and specifying energy-efficient products. Executive Order 12902 (§507) and the Energy Policy Act of 1992 (EPACT) direct all Federal agencies to choose energy-using products which are among the 25% most energy-efficient products available, or at least 10% more efficient than required by Federal standards. Such products must also meet the agency's requirements and be cost effective.

In September 1995, 22 agencies, representing over 95% of Federal purchasing power, signed what was then called the Energy Efficiency and Resource Conservation Challenge, now simply referred to as the Procurement Challenge. These agencies committed themselves to provide leadership in energy-efficient purchasing. The purpose of the Challenge is to assist agencies in meeting the energy and water conservation goals of EPACT and Executive Order 12902.

DOE issues *Product Energy-Efficiency Recommendations* for certain energy-using products that are:

- widely purchased by Federal agencies;
- use a significant amount of energy;
- offer a range of efficiencies (above any mandatory standard); and
- have a generally accepted method of testing and reporting energy performance.

The *Recommendations* are easy-to-use, two-page summaries that provide Federal buyers with information on the efficiency level for products that comply with the requirements of Executive Order 12902. They also provide information on cost effectiveness, buyer tips, and where to find additional information. *Recommendations* are being issued

for more than 50 products. See Appendix A for a list of these products and a sample *Recommendation*.

In addition, DOE has been working with the General Services Administration (GSA) and the Defense Logistics Agency (DLA) to designate products that meet or exceed the efficiency levels included in the *Recommendations*. Agencies can achieve major savings in energy operating costs by purchasing products from GSA and DLA with the **$^{E}_{E}$ designation**.

The Federal government represents the single largest customer in the world for most energy-using products, spending $10 billion to 20 billion a year on them. The annual energy bill to operate Federal buildings and facilities is $3.7 billion. Lower energy use also means reduced greenhouse gas emissions over the life of the product. By providing a large, reliable market for energy-efficient products, Federal purchasing helps lower the costs of these products for all consumers and provides a model for other levels of government and for corporate and institutional buyers. See Appendix A for more product information on product recommendations.

Specifying recycled or 'recovered' materials content is an important step in helping to close the materials loop. EPA has been tasked by Executive Order to assist this process in the Federal government in this effort by streamlining the process for designating these types of items. The EPA issued the Comprehensive Procurement Guideline (CPG) in the *Federal Register* on May 1, 1995 designating 19 new items containing recovered materials. Additionally the EPA published a "Recovered Materials Advisory Notice" (RMAN) recommending recycled content ranges and procurement practices for each product. Included were recommendations for the 19 products, and revisions of previous recommendations for products such as building insulation and concrete containing fly ash. A total of 24 products have been covered to date. In addition to the CPG and RMAN, EPA has generated detailed fact sheets on each of the 24 products.

Note that if (1) your agency is a procuring agency and (2) is purchasing $10,000 or more of a designated product, or purchased $10,000 or more of a designated product in the preceding fiscal year, then the agency is required to purchase EPA-designated products.

For facility managers, the current EPA-designated products of interest are concrete, building insulation, patio blocks, paper products, office waste receptacles, structural fiberboard, traffic barricades, and traffic cones.

In addition to the CPG and RMAN, under RCRA §6003, Federal specification writing agencies are required to examine their specifications that prohibit the use of recovered materials.

Contacts

To obtain copies of the *Product Energy-Efficiency Recommendations*, call the FEMP Help Desk at (800) DOE-EREC or visit the FEMP Home Page at http://www.eren.doe.gov/femp.

To obtain copies of the Comprehensive Procurement Guideline as listed in the Federal Register, the RMAN, or Fact Sheets, visit the EPA Home Page at http://www.epa.gov.

Many of the objectives of this guide can be greatly assisted by forming partnerships with capable organizations external to the government. One group of organizations that can readily provide assistance are the local utility companies, who supply electrical power, natural gas, and water, and who process waste water and solid waste. The current regulatory climate often makes it more profitable for the local utility to assist its customers, including the Federal government, to use less of the energy and water resources they provide. Another type of business, Energy Service Companies (ESCOs), can make capital investments in energy improvements in return for a share of the savings.

Action Moment

It is good practice on the part of any facility manager to be thoroughly familiar with the programs offered by the local electric, gas, water, and wastewater utilities. They will generally have a broad range of incentive programs for helping their customers use less resources. The laws governing utilities and Public Utility Commissions provide incentives for many utilities to actually sell less energy and other resources and profit from this—a truly extraordinary shift in thinking. The rapid move toward utility deregulation will probably reduce the availability of DSM programs and other types of utility incentives.

Technical Information

In an era of decreasing Federal resources, private sector partnerships will be critical for financing energy saving projects. There are a variety of programs that facility managers can use to take advantage of private-sector capabilities to reduce energy- and water-resource consumption and costs: utility partnering, using energy services companies, cogeneration programs, and fuel acquisition. An additional important factor is the deregulation of the electric utility industry. Learning how to purchase electricity at the lowest possible cost will become increasingly significant. Utilities often are interested in retaining their large Federal customers. This gives the facility manager a real advantage when working with a utility.

Virtually every electric utility in the country has a range of energy conservation services available to help the facility manager reduce energy consumption and costs. The utility will generally have personnel with experience and expertise in energy audits and will often provide their services free. They can recommend a wide range of measures—energy-efficient lighting, control systems, building envelope modifications, and many others.

These programs are often in the form of area-wide contracts (AWCs) or Basic Ordering Agreements (BOAs) available for use by Federal agencies located in the utility's service territory. These programs allow the Federal government to implement energy and water conservation measures through financing provided by the utility. AWCs and BOAs are used to provide general terms and conditions of the contract for ease in procuring these programs.

Energy Savings Performance Contracts (ESPC), authorized by the Energy Policy Act of 1992, and utility incentive programs, offer ESCOs and others ample incentives to improve the energy efficiency of Federal buildings. These incentives apply whether the building is leased or owned.

ESPC, formerly known as Shared Energy Savings Contracting, offers alternative financing of energy and water efficiency improvements in Federal buildings. By employing ESCOs the Federal government retains a portion of the energy savings and all the equipment they install. ESCOs can provide turnkey services and derive their income from the savings experienced by their customers. In effect the capital required to accomplish the upgrades is provided by the ESCO instead of having to be obtained through the usually long and laborious Federal budgeting process.

ESPC and other programs can be used when: (1) updating aging equipment with newer, more efficient products; (2) helping agencies meet the energy cost reduction goals of Executive Order

12902 and the Energy Policy Act of 1992 (EPACT); (3) conserving nonrenewable fuels and achieving environmental benefits by reducing energy consumption; and, (4) reducing utility costs without sacrificing service.

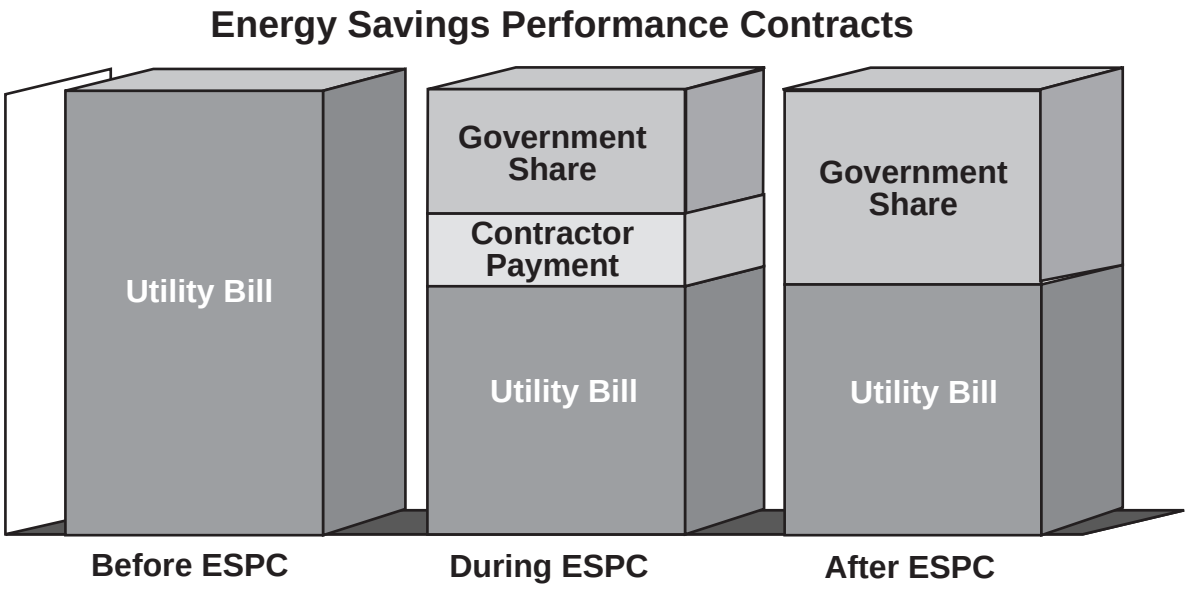
A broadening and simplification of energy savings performance contracting (ESPC) is being developed by the Department of Energy, Federal Energy Management Program. ESPCs are a contracting method whereby the contractor incurs the cost of implementing energy savings measures-including performing an audit, designing the project, acquiring and installing the equipment, training personnel, and operating and/or maintaining equipment-in exchange for a share of the energy savings directly resulting from such measures during the term of the contract. Current procedures that have resulted in site-specific facility contracts will be modified to allow the development of regional contracts, known as **FEMP Energy Savings Performance Contracts** or **Super ESPCs.**

Super ESPCs will deliver performance-based energy services and will be available to Federal agencies with Government-owned facilities within a region through delivery orders executed under a regional Indefinite Delivery Indefinite Quantity (IDIQ) contract under the Federal Acquisition Regulation (FAR) process. These new ESPCs will involve the competitive selection of a small number of contractors (multiple awards). Federal agencies then have the option of placing delivery orders against the contract and selected energy service companies would be allowed to conduct negotiations with individual facilities.

FEMP has developed model procurement documents and two workshops on ESPC and utility financing mechanisms. The workshops teach Federal employees how to fully develop energy savings performance contracts successfully. Workshop I covers methods for: (1) identifying energy-conservation measures; (2) determining if the project economics are sufficient for a contract; (3) developing procurement documents; and, (4) executing the contract. Workshop II is an optional hands-on session to assist participants in refining their specific projects and covers: (1) developing a Statement of Work; (2) establishing proposal requirements; (3) establishing criteria for award; and, (4) preparing a *Commerce Business Daily* synopsis.

Contact

The schedule for FEMP Workshops on ESPC can be obtained by calling the FEMP Help Desk at (800) DOE-EREC or by fax at (202) 586-3000. FEMP's address: Federal Energy Management Program, EE-90, U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585-0121.



Incentive programs are an excellent way to produce change in an organization. Rewarding good ideas with tangible benefits not only helps those who take the time and effort to put forward ideas on how to increase energy efficiency and reduce waste, but helps motivate others to perform in a similar fashion. The Federal government has a long and successful history of incentive programs to motivate its workforce to save money. More recent versions provide financial incentives for employees to suggest how to save money due to reductions in water and energy consumption. A sophisticated incentive program can help dramatically reduce the energy and environmental impacts of the facility.

Action Moment

When implementing a broad range of energy and environmental actions to "green" their operations and functions, facility managers can use incentive programs to stir up a high level of interest in the greening effort.

Technical Information

Facility managers should note that in addition to incentive programs they may be trying to promulgate, utility companies also have incentives to serve the government as client and consumer. Utilities can now earn revenue by providing energy-efficiency services and technologies to both owner-occupied and leased buildings.

1 **The Energy Policy Act of 1992 (EPACT)** and Executive Order 12902 encourage energy efficiency in workspaces leased by Federal agencies. By improving energy efficiency in their leased space, agencies can derive energy savings benefits with a corresponding benefit for taxpayers. EPACT offers Federal agencies the opportunity to participate in any and all electric and gas utility incentive programs that utilities offer to their non-Federal customers.

2 **Utility incentives include rebates,** customized services, bidding programs and other offerings. In utility incentive bidding programs, tenants, owners, utilities, and energy service companies (ESCOs) work together as a team to create energy-efficient systems.

Group incentive programs can be just as important as individual incentive programs. For example, in DOD, agencies can use up to 40% of savings from their energy conservation efforts for quality-of-life improvements at military bases and other facilities. It is not difficult to convince Base Commanders of the worth of these programs, as it provides them with valuable resources in an era of money shortages and budget cuts.

3 **The standard Federal suggestion program** is also a good vehicle for creating a pathway from an employee with good suggestions to the facility manager. This program can be enhanced by conducting broadly delivered classes or training sessions that specifically address energy and environmental problems and the role of the standard suggestion program in tackling these problems.

4 **An annual award called the Federal Energy and Water Management Awards** is presented by DOE in conjunction with the Federal Interagency Energy Policy Committee (the "656" Committee). The program recognizes outstanding achievements in the efficient use of water and energy, the use of renewable energy sources, and cost-beneficial landscaping practices by the Federal government. Renewable measures include, but are not limited to, photovoltaics, solar thermal, passive solar design, biomass, wind, geothermal heat pumps, and low-head hydro dams. FEMP coordinates this program for the Federal government.

Contacts

For additional information on the FEMP Awards Program, contact the FEMP Help Desk at (800) DOE-EREC.

Product Energy Efficiency Recommendations | Appendix A

Each year, the Federal Government purchases an estimated $10 to $20 billion in energy-related products and pays an $8 billion energy bill. Nearly half of this energy cost is in buildings alone. There is an enormous opportunity for savings, and one conspicuous target is the purchase of efficient energy-using equipment. Energy-efficient procurement has three strong positive impacts.

1 **First and foremost,** it saves agency and taxpayer dollars. The great majority of energy-efficient products sell at small or nonexistent first-cost increments.

2 **Second, energy savings** from more efficient models translate to less pollution. Annual electricity savings from typical use of a 36,000 btu/hour central air conditioning unit with a 12 Seasonal Energy Efficiency Rating (SEER), compared to a 10 SEER unit is 600 kilowatt-hours. This means that, on average, 900 pounds of CO_2, 9.2 pounds of SO_2, and 3.3 pounds of NO_x emissions will be prevented from entering the environment yearly. CO_2, SO_2, and NO_x are the principle pollutants responsible for global warming, acid rain, and smog, respectively, and are by-products of fossil fuel-powered electricity generation.

3 **The third substantial benefit** of the government's buying more efficient products is that it "pulls" the overall market for these products upwards, as economies of scale cut costs for the more efficient products, while greater demand spurs innovations in efficient designs. This serves to strengthen the companies in these markets, as well as further reducing costs to users and further diminishing pollution.

The Department of Energy is trying to let government purchasers know what is energy-efficient and what is not. President Clinton's Executive Order 12902, in conjunction with the Energy Policy Act of 1992, has established a clear mandate to agencies to use life-cycle costing analysis in their purchasing of energy-consuming equipment, and where practicable, to purchase in the upper quartile (top 25%) of energy efficiency within comparable classes of products. Pursuant to this, DOE is creating simple two-page guidelines called *Product Energy Efficiency Recommendations*. The *Recommendations* identify this upper quartile of efficiency in several dozen common energy-using products, and let government purchasers see the lifetime savings that will accrue from purchasing these instead of comparable but less efficient models.

Included in the next few pages are two of the Recommendations, on room air conditioners and exit signs. The Recommendations are available for no charge. For an ordering brochure, call (800) DOE-EREC.

How to Buy an Energy-Efficient Room Air Conditioner

Energy Efficiency and Renewable Energy
Federal Energy Management Program

Why Agencies Should Buy Efficient Products

- *Section 161 of the Energy Policy Act of 1992 (EPACT) encourages energy-efficient federal procurement. Executive Order 12902 and FAR section 23.704 direct agencies to purchase products in the upper 25% of energy efficiency.*
- *Agencies that use these guidelines to buy efficient products can realize substantial operating cost savings and help prevent pollution.*
- *As the world's largest consumer, the federal government can help "pull" the entire U.S. market towards greater energy efficiency, while saving taxpayer dollars.*

Efficiency Recommendation

Product Type and Cooling Capacity	Recommended EER[a]	Best Available EER
with louvers[b]; < 6,000 Btu/hr	9.2 or more	10.0
with louvers; 6,000-19,999 Btu/hr	10.0 or more	11.7
with louvers; ≥ 20,000 Btu/hr	9.2 or more	10.0
without louvers; all cooling capacities	9.2 or more	9.5

a) Based on DOE test procedure; see 10 CFR 430, Sup-part B, Appendix F.

b) Louvered sides improve the energy performance of window-installed A.C. units by enhancing airflow over the outdoor coil. Units intended for through-the-wall installation require a smooth-sided cabinet (no louvers).

Definitions

Cooling Capacity is the amount of cooling that can be provided by the unit (in Btu/hr) at standard rating conditions.

EER, or Energy Efficiency Ratio, is equal to the measured cooling capacity of the unit (in Btu/hr) divided by its electrical input (in watts) at standard rating conditions.

Where to Find Energy-Efficient Room Air Conditioners

The federal supply sources for room air conditioners are the Defense Logistics Agency (DLA) and the General Services Administration (GSA). DLA's FED LOG purchasing software includes EERs of room air conditioners. GSA sells room air conditioners through Schedule 41-I, as well as through its on-line shopping network, *GSA Advantage!* (starting in 1999). Look for products that meet the recommended efficiency levels.

When buying from a commercial source (retailer or distributor), choose models that qualify for the EPA/DOE ENERGY STAR® label (see "For More Information), all of which meet the recommended levels. Some manufacturers and retailers display the label on complying models. Alternatively, look at the yellow "EnergyGuide" label to identify models with EERs that meet these Efficiency Recommendations. For a contractor-supplied air conditioner, specify an EER that meets the recommended level for that type and size.

Federal Supply Sources:

- General Services Administration (GSA)
  Phone: (816) 926-2389 (Gail Allen)
  http://www.fss.gsa.gov
- Defense Logistics Agency (DLA)
  Phone: (215) 697-2429
  DSN 442-2429

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and World Wide Web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  http://www.eren.doe.gov/femp/procurement
- DOE has ENERGY STAR® room air conditioner model listings.
  Phone: (800) 363-3732
  http://www.energystar.gov
- American Council for an Energy-Efficient Economy (ACEEE) publishes the *Consumer Guide to Home Energy Savings.*
  Phone: (202) 429-0063
  http://aceee.org
- Consumers Union publishes the *Consumer Reports Annual Buying Guide*, and provides an on-line room air conditioner sizing guide.
  Phone: (800) 500-9760
  http://www.consumerreports.org
- Air Conditioning Contractors of America (ACCA) publishes *Manual J*, a load calculation guide for residential heating and air conditioning.
  Phone: (202) 483-9370
  http://www.acca.org
- *Home Energy* magazine provides energy conservation tips on air conditioning.
  Phone: (510) 524-5405
  http://www.homeenergy.org
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 484-0880

Sizing

Oversizing of air conditioners, besides raising purchase cost, will lead to excessive energy consumption and poor humidity removal due to excessive on-off cycling. The required air conditioner capacity should be determined based on the referenced ACCA or Consumer Reports calculation procedures (see "For More Information").

Environmental Tips

Refrigerants with ozone-destroying chlorofluorocarbons (CFCs) were used many years ago in room air conditioners but most existing equipment today uses HCFC refrigerants, which have a much lower ozone-depleting effect; ask your supplier for information. In the future, room air conditioners with ozone-safe refrigerants are expected to be available.

When retiring an air conditioner which contains CFCs or HCFCs, the Clean Air Act requires that the refrigerant be recovered prior to final disposal of the appliance. For compliance information, contact the EPA Stratospheric Ozone Information Hotline at (800) 296-1996.

Room Air Conditioner Cost-Effectiveness Example (10,000 Btu/hr - louvered)

Performance	Base Model[a]	Recommended Level	Best Available
EER	9.0	10.0	11.7
Annual Energy Use	830 kWh	750 kWh	640 kWh
Annual Energy Cost	$50	$45	$38
Lifetime Energy Cost	$500	$450	$390
Lifetime Energy Cost Savings	–	**$50**	**$110**

a) The efficiency (EER) of the Base Model is just sufficient to meet current U.S. DOE national appliance standards.

Definition

Lifetime Energy Cost is the sum of the discounted value of annual energy costs based on average usage and an assumed air conditioner life of 15 years. Future electricity price trends and a discount rate of 4.1% are based on federal guidelines (effective from April, 1998 to March, 1999).

Cost-Effectiveness Assumptions

Annual energy use in this example is based on the standard DOE test procedure for a louvered model with a cooling capacity of 10,000 Btu/hr and 750 operating hours per year. The assumed electricity price is 6¢/kWh, the 1996 federal average electricity price in the U.S.

Using the Cost-Effectiveness Table

In the example shown above, a room air conditioner with an EER of 10.0 is cost-effective if its purchase price is no more than $50 above the price of the Base Model. The Best Available model, with an EER of 11.7, is cost-effective if its price is no more than $110 above the price of the Base Model.

What if my Electricity Price or Operating Hours are different?

To calculate Lifetime Energy Cost Savings for a different electricity price, multiply the savings in the above table by this ratio: $\left(\frac{\textit{Your price in ¢/kWh}}{\textit{6.0 ¢/kWh}}\right)$. Similarly, for a different operating hours figure, multiply the savings by this ratio: $\left(\frac{\textit{Your operating hours}}{\textit{750 hours}}\right)$.

Metric Conversions

1,000 Btu/hr = 293 watts
*°F = (1.8 * °C) + 32*

How to Buy Energy-Efficient Exit Signs

Energy Efficiency and Renewable Energy
Federal Energy Management Program

Why Agencies Should Buy Efficient Products

- *Section 161 of the Energy Policy Act of 1992 (EPACT) encourages energy-efficient federal procurement. Executive Order 12902 and FAR section 23.704 direct agencies to purchase products in the upper 25% of energy efficiency.*
- *Agencies that use these guidelines to buy efficient products can realize substantial operating cost savings and help prevent pollution.*
- *As the world's largest consumer, the federal government can help "pull" the entire U.S. market towards greater energy efficiency, while saving taxpayer dollars.*

Federal Supply Sources:

- Defense Logistics Agency (DLA)
  Phone: (800) DLA-BULB
- General Services Administration (GSA)
  Phone: (817) 978-2792
  http://www.fss.gsa.gov

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and World Wide Web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  http://www.eren.doe.gov/femp/procurement
- Environmental Protection Agency has ENERGY STAR product listings.
  Phone: (888) 782-7937
  http://www.energystar.gov
- American Council for an Energy-Efficient Economy (ACEEE) publishes the *Guide to Energy-Efficient Commercial Equipment*, which includes a chapter on lighting.
  Phone: (202) 429-0063
  http://aceee.org
- Lighting Research Center's Web site has the ENERGY STAR specification and other valuable information covering exit signs and other lighting systems.
  Phone: (518) 276-8716
  http://www.lrc.rpi.edu
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 484-0880

Efficiency Recommendation

Product Type	Recommended	Best Available
Single Face	5.0 watts or less	1.8 watts
Double Face	10.0 watts or less	1.8 watts

Where to Find Energy-Efficient Exit Signs

The federal supply sources for exit signs are the Defense Logistics Agency (DLA) and the General Services Administration (GSA). DLA sells exit signs through its *Energy Efficient Lighting* catalog. GSA offers them through Schedule 99-IV, "Signs," as well as through its on-line shopping network, *GSA Advantage!* (starting in 1999). Select exit signs that meet the recommended levels. Both DLA and GSA also sell exit sign retrofit kits, which allow conversion of existing signs to energy-efficient light-emitting diode (LED) models.

For exit signs purchased through commercial sources, look for products with the EPA/DOE ENERGY STAR® label, all of which meet this Recommendation. For a contractor-supplied exit sign, specify products with the ENERGY STAR® label, or with power consumption (in watts) that meets the recommended levels.

Buyer Tips

Most light-emitting diode (LED) exit signs meet this Efficiency Recommendation for both single and double face configurations. Some compact fluorescent lamp (CFL) exit signs meet the double-face Recommendation; CFL models require lamp replacements about every 2 years compared with an estimated life of 10 years or more for LED lamps.

To ensure adequate visibility, the ENERGY STAR® label also requires that exit signs exceed visibility guidelines established by the National Fire Protection Association (NFPA) Life Safety Code 101, and most building code

requirements. Many LED and CFL signs meet these criteria. Be sure to check compliance with your own state or local codes before selecting exit signs.

Before purchasing exit signs, make sure that the manufacturer's warranty covers replacement of defective parts for at least 5 years from the date of purchase, as required by the ENERGY STAR specification.

Retrofits

Retrofitting existing exit signs may be more economical than replacing entire signs, but proper installation is vital to ensuring adequate visibility. The ENERGY STAR program does not cover retrofit kits.

Exit Sign Cost-Effectiveness Example (Double Face Model)

Performance	Base Model	Recommended Level	Best Available
Power Consumption	40 watts	10 watts	1.8 watts
Annual Energy Use	350 kWh	88 kWh	16 kWh
Annual Energy Cost	$21	$5	$1
Lifetime Energy Cost	$160	$40	$10
Lifetime Energy Cost Savings[a]	–	**$120**	**$150**

a) Note that these savings do not include lamp replacement costs, including labor, which are discussed in the text below.

Definition

Lifetime Energy Cost is the sum of the discounted value of annual energy costs, based on constant usage and an assumed exit sign life of 10 years. Future electricity price trends and a discount rate of 4.1% are based on federal guidelines (effective from April, 1998 to March, 1999).

Cost-Effectiveness Assumptions

The Base Model in this example uses two 20-watt incandescent lamps. The Recommended Level sign uses two CFLs, which draw 5 watts each (in combination with their ballasts). The Best Available model uses a 1.8-watt LED array.

Annual energy use in this example is based on constant use, or 8,760 operating hours per year. The assumed electricity price is 6¢/kWh, the 1996 federal average electricity price in the U.S. The calculations are for energy cost savings only, and do not include lamp replacement or labor costs. Considering lamp replacement and labor costs would significantly increase the total savings of a CFL sign relative to an incandescent, as well as the total savings from an LED sign relative to either a CFL or incandescent model. Over the 10-year life of an exit sign, the total number of lamps required would be approximately 30 incandescents, 10 CFLs, or a single LED array.

Using the Cost-Effectiveness Table

In the example shown above, cost-effectiveness is determined solely on energy savings, and excludes benefits from fewer replacement lamps and labor savings. A recommended exit sign with a power consumption of 10 watts is cost-effective if its purchase price is no more than $120 above the price of the Base Model. The Best Available model, with a power consumption of 1.8 watts, is cost-effective if its price is no more than $150 above the price of the Base Model.

What if my Electricity Price is different?

To adjust the Lifetime Energy Cost Savings in the table above for a different electricity price, multiply the dollar figures listed by this ratio: $\left(\frac{\textit{Your price in ¢/kWh}}{\textit{6.0 ¢/kWh}}\right)$.